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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This ZIM-SCI study guide introduces students to the idea of being a scientist by presenting activities on the difference between use of the five senses and use of equipment to make measurements (part 1), experiments involving use of the senses as well as use of measuring equipment (part 2), and an activity on the diagrammatic treatment of results (part 3). Information to help students understand scientific principles behind the experiments is included. Throughout the unit, students are encouraged to understand that measurements are never perfect, to recognize errors, and to judge how accurate their results might be. Part 1 activities include: using and trusting senses; measuring length, temperature, mass, time, and volume; making a sensitive balance; and calibrating a beaker. Part 2 experiments include mixing different substances; finding a melting point; measuring a pulse rate; and matching sounds. Instructions for presenting experimental results in the form of a histogram are provided in part 3. (JN)

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ZIMBABWE SECONDARY SCHOOL SCIENCE PROJECT

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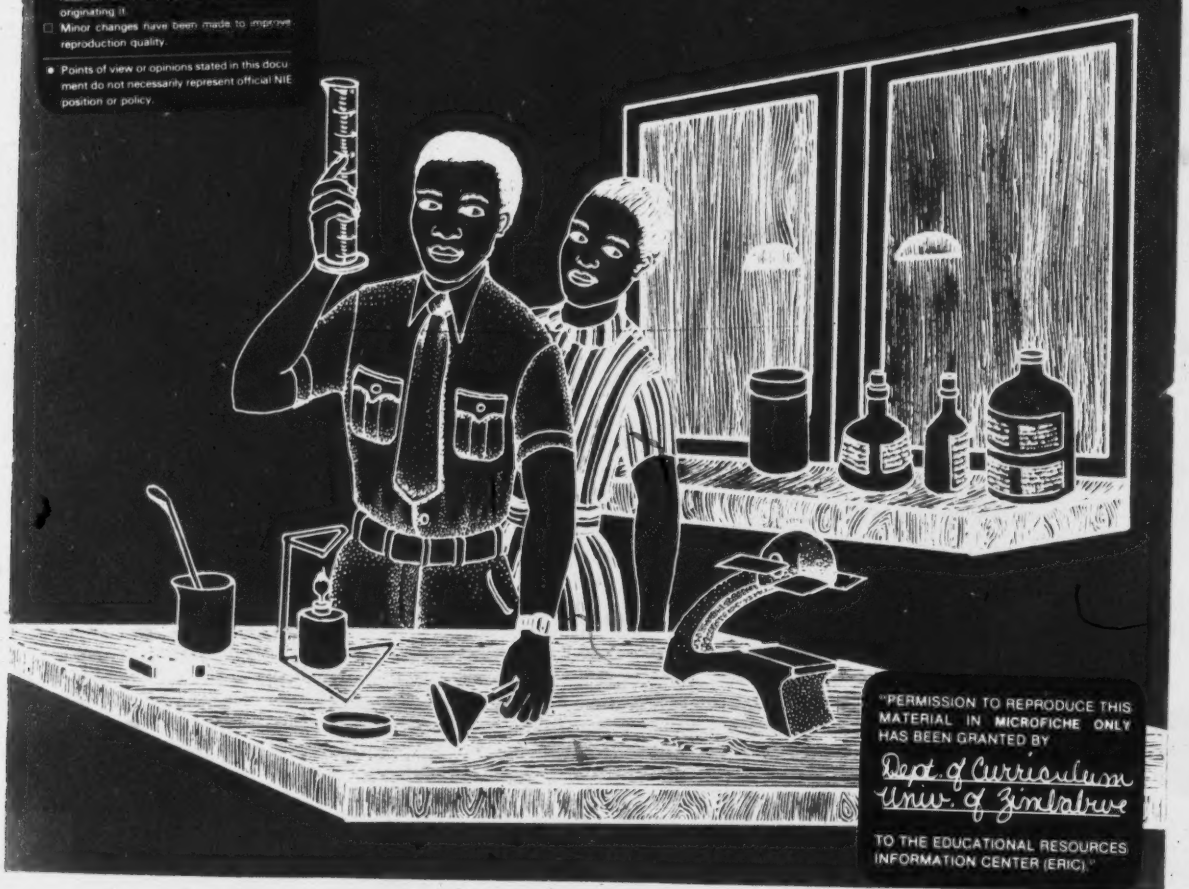

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STUDY GUIDE UNIT A1

Learning to be a Scientist

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

SE 043 828

VOL. 2

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March, 1981

Zim - Sci

Zimbabwe Secondary School Science Project

GENERAL SCIENCE

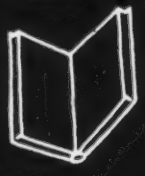
STUDENTS : Please read this carefully. It will help you.

How you will study

This study guide comes to you with a kit of apparatus. Both things are part of a study programme leading you to an understanding of aspects of science. In this course you will be carrying out experiments. The study guide will help you to understand the scientific principles behind the experiments.

Your work should be done as you are instructed, either by the teacher or the study guide.

To help you to see quickly what you must do, the study guide uses these symbols.



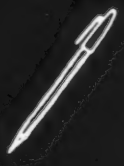
for "Read special notes".

for "Take note of an important point that you should learn."

for "Summary". This is to help you to go over what you have learned.

for "Experiment".
When you see this sign, read the instructions carefully from beginning to end before you start to do the experiment.

for "How much do you know?"
This is for you, to help you to test whether you are remembering what is important.



for "Written work". This is when you must answer questions in writing.

for Listen to the teacher and do exactly what the teacher tells you to do

(iv)

General Science

UNIT A1 : LEARNING TO BE A SCIENTIST

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Aims of Unit A1

When you have completed this first study unit you will be able to:

(1) list two ways in which our senses are not reliable.

(2) find the correct type and size of instrument to use for a particular measurement of length, volume, mass, temperature and time.

(3) state the units of measurement for length, volume, mass, temperature and time.

(4) read an instrument scale to the nearest division.

(5) demonstrate how to:

- (a) find the mass of a liquid in a container by difference,
- (b) graduate a small beaker,
- (c) measure the volume of a solid by displacement,
- (d) measure the thickness, volume and mass of one of many small objects by division,
- (e) construct a sensitive balance.

(6) write a description of the results obtained when different substances are mixed.

(7) explain that all measurements have errors and draw a histogram of a set of measurements.

(8) solve some simple scientific problems.

GENERAL SCIENCE UNIT A 1

LEARNING TO BE A SCIENTIST

PART 1

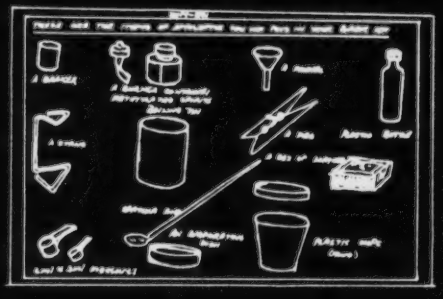
Today you are going to think about what it means to be a SCIENTIST. This is a word that you have heard before: perhaps you can even imagine a picture of a scientist at work? IMAGINE means "to think of something in your head". Think of a scientist now. Make a picture in your head. What does this person look like? I expect he is wearing a smart white coat in your imaginary picture, and he is very busy.

But what is he DOING? This is the important thing - scientists are men or women who look at the world around them and try to DISCOVER things about how the world works. They FIND OUT. You are going to look at some things today and see how much you can find out, just using your own brain and senses. What are your senses? They are:

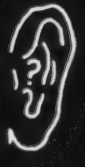
Open your science kit and take out all the APPARATUS. This is the word that scientists use for the TOOLS that help to find out things. Finding out is called EXPERIMENTING by the scientists.

Check off all the apparatus against the list by making a tick (✓) on your apparatus diagram inside the kit. Your teacher will call out the items slowly for you.

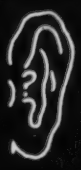
Find this diagram in your basic kit.



Have you found all the items? Good. Now look at the FUNNEL. Do not pick it up yet - leave it on the desk in front of you. What do your eyes tell you? It is a nice colour, isn't it? It is also an interesting shape. It looks as though it is smooth to touch too. Now listen to your teacher.



Your fingers and your eyes are very good tools for discovering more about the world. What other things do you have that help you to understand? That's right - your ears, nose and mouth. All of these are important. You will find out what your ears tell you now. Your teacher is going to bang with a stick on some glass, some wood and some metal. You must close your eyes again and try to guess which is which. Listen to all three first and then listen again. Make your guess. Were you right? Well done. Your ears are clever too!

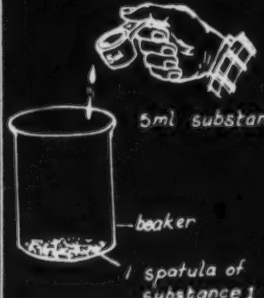


At the front of the classroom are three dishes. They contain three things that you eat every day. You will be asked to taste them and see whether you can guess what they are.

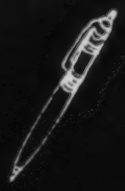
That was easy, wasn't it? Your sense of taste can tell you things too. Lastly you are going to use your sense of smell. You are going to make a substance called AMMONIA and see what it smells like.

EXPERIMENT 1 Making ammonia

Find your BEAKER in your basic kit.
Also find your 5 ml MEASURE



Put 1 spatula of Substance 1 (given by your teacher) into your beaker. Now pour in 5 ml of Substance 2. Smell the gas coming off. Horrid, isn't it? This gas is ammonia. Wash out your beaker and 5 ml measure.

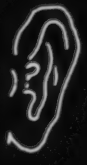


Fill in Exercise 1 now from the blackboard with the results that you have discovered today.

CAN WE TRUST OUR SENSES?

In the last part of the lesson, you learned how to use your senses to discover things. Each of your senses sent a message to your brain. Look at your exercise book again to remind you of what you found out from these messages

Today you are going to do some more experiments using your senses. You will begin with your eyes again, and use your eyes to explain some pictures that the teacher has on a big chart.



Look at the chart now - at Picture 1. Who thinks that the top line is longer? Who thinks the bottom one is longer? Who thinks that they are the same length? Your teacher will measure them now with a ruler.

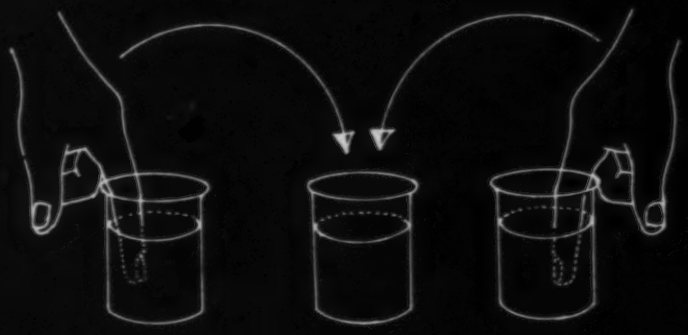
Now look at Picture 2. Who is the tallest person? Who thinks the man in front? Who thinks the one in the middle? Who thinks the man at the back? Let us measure them again.

Lastly, look at Picture 3. Who thinks the man is stabbing the buck? Who thinks the elephant? Your teacher will explain the diagram to you and discuss the other pictures with you.

So your eyes do not always tell you the truth! Sometimes as you can see, we get an idea from a picture or from our surroundings which is not correct. Our eyes are DECEIVING us!

Perhaps your sense of feeling cannot be fooled so easily?

EXPERIMENT 2 Feeling hot and cold



At the front of the classroom are three beakers of water. One is fairly hot, the second just warm and the third is cold. Put a finger of your left hand into the cold water and a finger of your right into the hot. Take them out and quickly put both your fingers into the middle beaker. How does the water feel to your left hand? And to your right?

Did your fingers send you different messages! Are they deceiving you too!

Your sense of smell is the next that we shall try.

EXPERIMENT 3 Using your nose

Your teacher will put a strong smelling chemical called naphthalene into a beaker. Smell this substance. Do you know this smell? Your teacher will now add a little ammonia in water and ask you to smell again!

Probably you can smell one substance or the other, but not both. So your nose cannot always smell everything that is there!

You are left with only hearing and taste to test for true messages! Your hearing test must be done outside.

EXPERIMENT 4 Using your ears

Look at this picture (Diagram 1). When the class is ready, your teacher will tell you what to do.

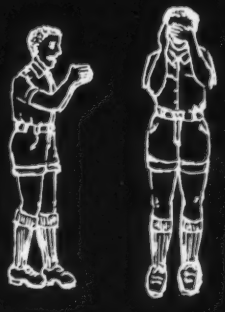
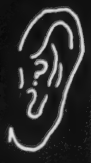


Diagram 1



So your ears can play tricks sometimes!

Lastly let us see whether your sense of taste will ever be unreliable.

EXPERIMENT 5 Tasting orange juice

Your teacher has some nice orange juice for you to taste. It is quite safe to have a sip - don't drink too much and leave none for the other pupils! After you have tasted the orange juice take a small amount of toothpaste. Rub it around your teeth, then spit it out, into the waste bucket. Taste the orange juice again. How does it taste now?

We use our senses all the time, and they usually tell us the right things. However, as you have seen they cannot always be relied upon to tell us the truth.

Scientists want to find out things. Why is this? Firstly, they want to know more about the world around them because they feel happy when they understand how things work. Secondly, they want to TELL OTHER PEOPLE about how things behave. To be able to tell others, they must know EXACTLY what to tell them.

Think about your mother cooking your meal. She will put some salt in. She knows how much salt to add - too much would taste very bad. The cooking would fail because the meal could not be eaten. If she is teaching you how to cook, she will tell you how much salt to add.

In just this way, scientists pass on instructions and information. These instructions must be very good so that other scientists can repeat the experiments exactly. We have seen that the senses cannot give exact information, so scientists use aids to help them. These aids are always MEASURING instruments. They tell how long, how heavy, how hot, how MUCH of something should be used. They are much more accurate than our senses can ever be.

MEASUREMENT : LENGTH

What are our aids to measurement? You have been using a RULER for many years now and have been taught how to measure LENGTH. A ruler is sometimes too short, however, for general scientific use and so for longer measurements the scientist uses a METRE RULE.

The SCIENTIFIC UNIT of length is the metre (m)

As its name suggests, a metre rule is just one metre long. It is divided into centimetres just like your ruler: there are of course 100 of these smaller divisions. Each centimetre is further divided into millimetres.

1 000 mm = 100 cms = 1 metre

Your teacher has a metre rule to show you now. Pass it round the class and have a look at it. Get a good idea of its length so that you could make a guess at one metre if you have to in the future.

Now look at the classroom wall. How many metres long do you think it is? Write down your guess in your exercise book (Exercise 2) You will need to use your estimate again later. Your teacher will put all the guesses on the board.

Your teacher is going to measure it now using the metre rule so that you can all see how well you guessed. How close were you? Do not feel bad if your guess was far out. That means that you have not had much practice in the idea of estimation. You will get better as you do more.

How good was the teacher's measurement? Do you think it was EXACTLY right? Or was it correct to the nearest metre? centimetre? millimetre? Tell the teacher what you think. He will be able to tell you how exact his measurement was. He will also be able to show you that the metre rule has an ERROR no matter how careful you are.

EXPERIMENT 6 Measuring length

Your teacher will put you into 2 groups now. Choose five from each group. These five are going to measure the length of the teacher's desk. Another member of the group is going to write down each result without anyone else hearing the answer. If anyone in the group thinks of an idea to help to make the measurement MORE ACCURATE then he can put his idea to the others.

At the end of this, you will have ten different measurements from the ten measuring people. You will see that the ten measurements are not the same. They are spread out. For example, suppose five of the readings are:

1,71 m
1,76 m
1,72 m
1,71 m
1,70 m

The measurements are spread out between 1,70 m and 1,76 m. We can say that the length of the bench is close to 1,7 m but we cannot be absolutely certain about the second decimal place.

Any measurement that we make, using any piece of apparatus, will have some error that we cannot do anything about. We should always be aware of this when we are taking measurements and not try to pretend that we are being very accurate if we are really taking a rough measurement only.

In your exercise book, write the measurements that the class obtained. Also write your accurate answer in the space provided. Your teacher will help you to estimate this.

So, in the lesson today you have learned some very important things. You have learned about taking a rough estimate of a measurement, then how to measure a length accurately, and lastly to understand how good your measurement is. Do not forget these ideas: you will need them again and again as you go on with your science lessons.

MEASUREMENT : TEMPERATURE

Now you have learned about measuring length, we shall turn our attention to how hot something is. This is called TEMPERATURE. The units of temperature are DEGREES CELSIUS. You have often heard weather reports in which the forecast gives the expected temperature for the next day. The temperature of the air on a warm day in Zimbabwe is around 27^{o}C - twenty seven degrees Celsius. Your body temperature is 37^{o}C. Before we go on to the measurement of temperature let us see how good you are at ESTIMATION.

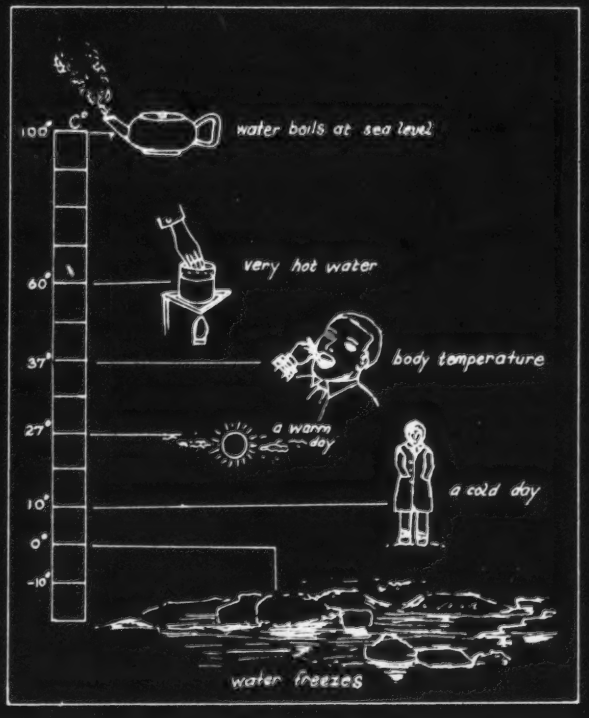
Your teacher has some warm water on the bench. You are asked to make a guess at the temperature of the water. Return to your exercise book and write down your guess just as you did for the length of the classroom wall. Before you go, read and remember the guide below:

TEMPERATURE GUIDE

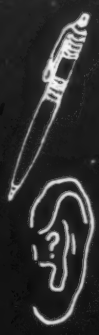
If it feels cold to your fingers it is below body temperature of 37°C

If it feels colder than other similar objects, it is colder than room temperature.

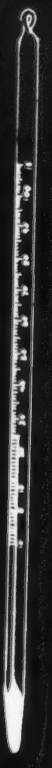
If it is too hot to hold, it is above 60°C



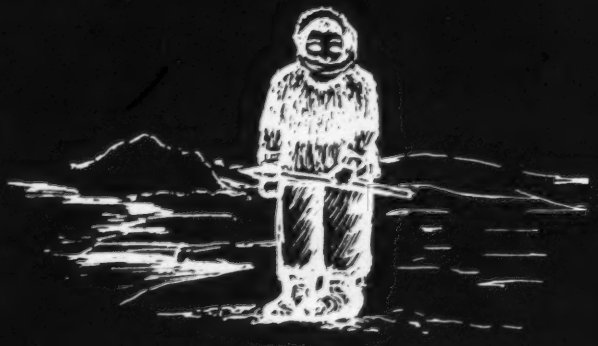
So if it feels warm to you, you should guess between 37°C and 60°C. After that it is up to you! Go and have a try now.



Have you written your guess in your exercise book (Exercise 3)? Your teacher would like to hear all your guesses now. After writing them on the board, you will be given the teacher's result obtained by using an instrument more accurate than your finger. You will be able to see how close you were. Write the given result in your book also.



Scientists measure temperature with a thermometer. Look at a thermometer now. You will see a scale written on the glass, divided into degrees. We have a problem here though, which we did not have with length measurement. Put your ruler next to the thermometer and find the zero position on both instruments. What does the zero on the ruler tell you? That is right - no length at all. What does the zero on the thermometer tell you? Does it mean that a body has no heat at all? What do you think about this? Discuss this question with your teacher.

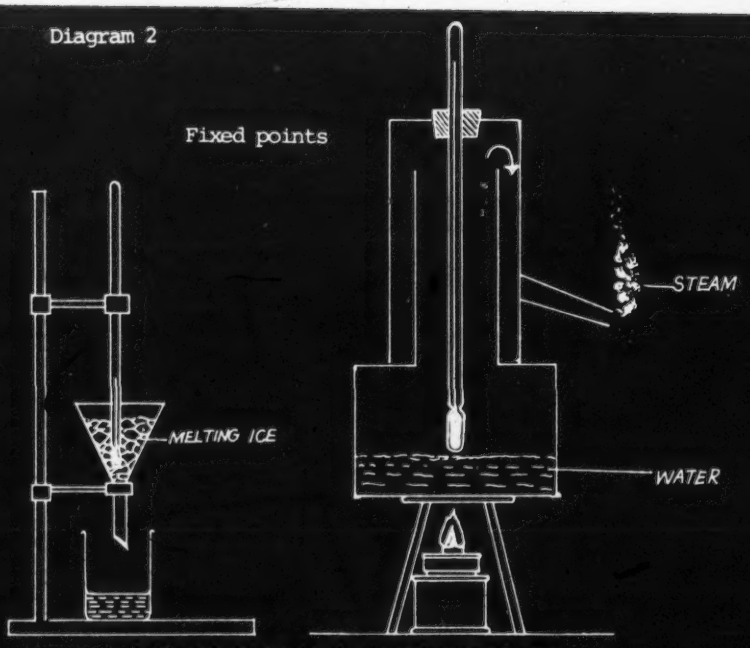


An Eskimo lives in a very cold place!

Matopos, August 1972!

Diagram 2

Fixed points



A thermometer is designed around two temperatures, those of melting ice and boiling water. These are called the FIXED POINTS of the thermometer. Between these points we have 100 divisions called degrees. Other temperatures are measured using this scale: the CELSIUS SCALE OF TEMPERATURE.

Below (Diagram 3) are two thermometers reading different temperatures. In your notebook, record what you think they say. If you find reading the scale is difficult, ask your teacher to help you.

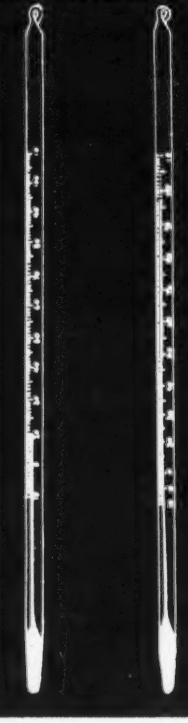


Diagram 3

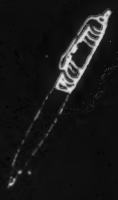
20

Now we shall do some actual measurements.

EXPERIMENT 7 Taking temperatures

Your thermometer has been lying on the bench for some minutes now. The measurement it shows is the temperature of the air. What is it? Record your room temperature in your exercise book. Now go and find out two more temperatures: that of the cold water in a bucket and that of the warm water you looked at before. This will have cooled down a bit so it will be different. You must keep the thermometer in the water for about a minute to make sure that the thermometer has time to measure the temperature. Write the answers in your exercise book.

Lastly, how good do you think your measurements are? What is your error? Look at your thermometer scale and see how accurate you think you can be. Can you read to the nearest degree? Half a degree? Record your estimate in your workbook.



Well done! You have worked hard at this lesson and now you can measure temperature very well. Don't forget your rough guide to estimating temperature, it may come in useful later.

Your teacher will show you another form of thermometer now, to finish this part of the lesson.

MEASUREMENT : MASS

What is mass? Perhaps you already know the word 'massive'? The idea that this word gives you is of something very big and solid. The word 'mass' really means how much stuff or "MATTER" something contains. This is a difficult idea to understand quickly: let us take a few examples and then the idea of mass will be clearer to you.

EXPERIMENT 8 : Estimating masses

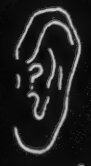
Find your bottles in your basic kit. Fill one with water. Leave the other empty. Pick them up, one in each hand. Which one do you think has the most MATTER in it? The more it has, the more you will feel it pulling down your hand. Put down the empty bottle. Still keep hold of the one full of water. Now imagine you are holding a brick in your empty hand. Which hand would be holding the most matter now? Does a brick or the bottle of water have the most mass?

Now answer Exercise 4, Question 1 in your exercise book.

How did you know that the full bottle had more mass than the empty one? You felt the full bottle pulling down your hand. A brick would have pulled it down even more! This "pulling down" feeling is because the brick wants to fall to the floor. The force which pulls it down is called GRAVITY.

When we MEASURE mass, it is no good feeling with our hands. Our senses cannot tell us EXACTLY how much stuff something contains. So we use the "pulling down" idea. The instrument which measures the pulling down of the mass is called a BALANCE. Sometimes a balance has 2 sides, like you have 2 hands and the pulling down effect is used to find out which mass is bigger. When the mass if pulled down by gravity we call it WEIGHT.

The units of mass are kilograms. We usually write this in short form as "kg". A kilogram may be divided into 1 000 divisions called grams. We write grams in a short form as "g".



What is your mass? Do you know?

Your teacher will now show you a balance which measures masses up to 900 g or 0,9 kg.

Listen as he explains how it works.

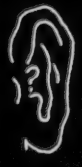
Now answer Exercise 4, Question 2.

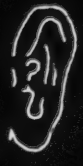
Now that you understand the balance, you can measure some masses for yourself.

EXPERIMENT 9 Masses on a balance

Find your two bottles again, then take them to the front of the class. Your teacher will tell you what to do next.

When you have found out about your bottles, answer Exercise 4, Question 3.





Why do you think the bottle with the sand had the biggest mass? Perhaps your teacher can give you some ideas?

Lastly in this part of the lesson you are going to make a balance for yourself. It will be a very good balance for measuring VERY SMALL MASSES. It will even show you the mass of a pin!

EXPERIMENT 10 To make a balance for measuring small masses

You will need:

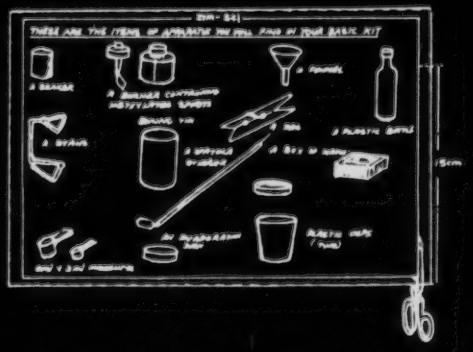
5 paper clips
A straw
2 pins
Your matchbox
Your peg
Your apparatus diagram
Some scissors
A piece of paper

Diagram 4

completed balance

Look at Diagram 4 This is what your balance will look like when it is finished. Here is how to make it.

1



First, find the diagram of apparatus in the basic kit. The short sides have wider margins than the long sides. Measure 15 cm along the short side and cut off the margin as shown. Mark the 15 cm mark using a ruler, and use the teacher's scissors to cut off the paper.
While one of you is cutting off the margin, the other member of the pair can be fixing up the matchbox. Just use the outside cover of the box, and tear off part of the brown sides as shown.

2

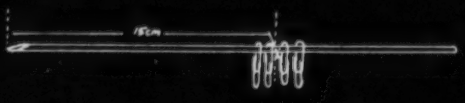
Now prepare the paper clips. Squeeze the end of each one slightly so that it is not as wide as before. It should fit tightly over the straw.

3

Squeeze this end a little bit.

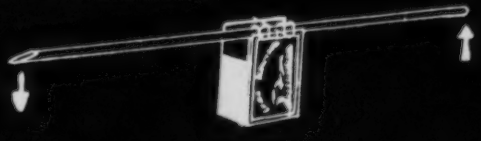
Now you are ready to go! One end of your straw has a v-shaped cut in it. Put this next to the zero mark on your ruler. Measure off 15 cms along the straw and push a pin through the middle of the straw at this mark. Make sure that the v-shaped cut is on the upper side as you do this. Now push the squeezed end of the paper clips onto the straw, two close together on each side of the pin.

4



Hang the pin across the top of the matchbox so that the straw swings freely.

5



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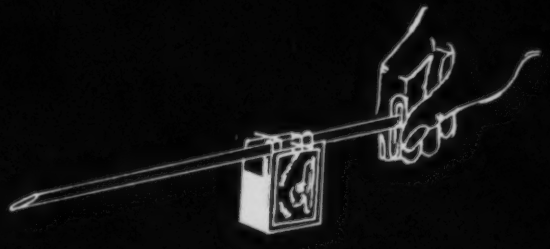


Tip the straw by pushing the last paper clip onto the straw at about the 19 cm mark. This does NOT have to be exact: the idea is that the end of the straw should NOT touch the desk. It should almost touch, however. Leave the paper clip in this position.

Tap the cut end gently to make sure that the straw is swinging freely.
Your balance now works but can it measure?
It needs a scale!

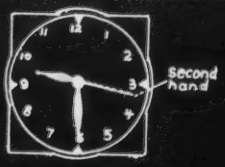
Find your peg and the piece of paper the teacher gave you.
(NOT YOUR CUT STRIP THAT YOU MADE EARLIER!)
Fold the paper in half to make a narrow piece. Place the piece of paper held in the peg behind the straw as shown in Diagram 4. This will be your scale. Put a mark on the paper at the point where the cut end of the straw rests. This is the zero mass mark. Your cut strip that you cut from the margin is going to form a set of known masses, so that you can mark the scale correctly!

The strip has a mass of 0,1 g. Mark and cut up the strip into 10 pieces each 1,5 cm long. Each of these has a mass of 0,01 g. Put one on the straw, pushing it into the cut end. The straw will go down a little bit, because of the pull of gravity on the paper. This is how you are going to mark the scale. Make a mark where the straw rests now. This is the 0,01 g mark. Continue to add pieces of paper and mark the scale until you have reached a mass of 0,1 g. (10 pieces of paper)

Now your balance is complete! Take all the pieces of paper off the straw. Check that it returns to the zero mark. Now hold the straw and put a pin into the cut end. Find out the mass of the pin.

Now answer Exercise 4, Question 4.

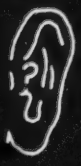
That was well done! You needed a lot of skill to make that balance, and you have made a sensitive and accurate instrument which you will use again later in the course.



MEASUREMENT : TIME

We come now to a very familiar measurement for you: the measurement of time. As you well know, time is measured in hours, minutes, seconds etc. The SCIENTIFIC UNIT of time is the second, as this is the most useful one for scientists. Often you will see minutes mentioned too.

60 seconds = 1 minute



Your teacher will show you the Zim-Sci clock. There is a "sweep second hand", that is a fast-moving hand that goes right around the clock in one minute. Watch it go round and get an idea of how long a minute is.

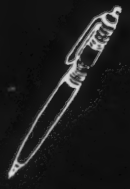
When you feel you know how long a minute is you are ready to try to estimate.

EXPERIMENT 11 : Estimating a minute

Read through all the instructions before you start.

Sit with your back to the clock. Your partner will be looking at the clock and will say "go!" when the second hand passes the twelve. You must call "One minute" when you think a minute has passed. You and your partner should then change places to allow your partner to do the estimating while you watch the clock. Make a note of how many seconds actually passed each time when the "one minute" call was made. Repeat this experiment several times and record each of your estimates.

Now answer Exercise 5, Question 1



How close were you? It's not easy to estimate time, is it?

Now for another experiment measuring time. You and your partner will each do this, as before.

EXPERIMENT 12: A timing exercise

Read through all the instructions before you start.

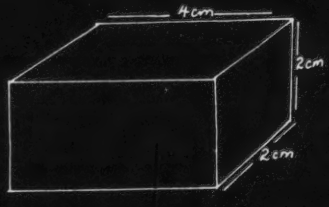
One partner from each pair should stand outside the door. The other partners should watch the clock and your teacher will say "Go!" as the second hand passes the twelve. The runners should run RIGHT ROUND THE BUILDING. As your partner comes back through the door, note the time in MINUTES AND SECONDS that he took to run around. Then it will be your turn!

Answer Exercise 5, Questions 2 and 3 now.

MEASUREMENT : VOLUME

Volume is the last quantity that you are going to learn to measure. Probably you have met the word before in arithmetic lessons in Primary School, but we shall go over the meaning in case you have forgotten.

Volume means "how much space" something fills. If something is very large, it has a big volume. You probably did some exercises in arithmetic like this:



"Find the VOLUME of the box"
Answer: VOLUME =
4 x 2 x 2 cubic centimetres
or 16 cm^3

Remember? The ^{3} showed that there were three directions in the box: length, width and height. Volume ALWAYS has three directions: because of this the units have to have the ^{3} idea in them. So we could have m^3 (CUBIC METRES) cm^3, mm^3 (CUBIC MILLIMETRES) etc. The SCIENTIFIC UNIT of volume is m^3, but the others can be used too.

Remember your bottles of sand and water? They had the same VOLUME because they filled the same space. The bottles also had the same space INSIDE THEM, so they could hold the same volume in each.

We often need to know how much space there is INSIDE something. It is very useful for measuring liquids. Liquids are often measured using a different unit: the LITRE. Perhaps you have met this unit before? It is written in short form as l.
Your mother might meet it when she is shopping, because many things in the shops are measured in litres or in parts of a litre.

What parts? Well, a litre can be divided into 1 000 parts, and these are called "millilitres". The short form of this is "ml". Find your 2 ml and 5 ml measures in your basic kit. Look at them. The 2 ml measure holds $\frac{2}{1000}$ of a litre INSIDE IT. The 5 ml holds $\frac{5}{1000}$. We can match up these units with our other ones, because $1\ ml = 1\ cm^3$

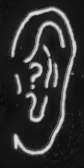
You are going to do an experiment now which will be of use to you in the future. Find your beaker in your basic kit. This beaker will be used for measuring volumes of liquids: it holds about 50 ml altogether. But it has no marks on it! You are going to put the measuring marks on the side of the beaker. Making the measuring marks on an instrument is called CALIBRATION.

EXPERIMENT 13 : To calibrate a beaker

You will need:
- 5 ml measure
- beaker
- a pen
- some water

Fill the 5 ml measure with water. Pour it all into the beaker. With your pen, mark "5 ml" on the outside of the beaker level with the top of the water. Take a measure of water again and add it to the water in the beaker. Now mark "10 ml" on the side. Go on in this way until you reach the top. Keep this beaker full of water for the moment: you will need it again.

Now your beaker can measure many different volumes of water. The marks you have made on the side are called GRADUATIONS. Be careful not to rub them off whenever you have to wash the beaker, or you will have to do the exercise again. Perhaps you can think of a more permanent way of marking your beaker. In future we shall refer to the beaker as a "graduated beaker". You have now made an important measuring instrument of great use. Your teacher will show you a big glass measuring instrument and explain some important points about using it.



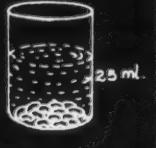
Your teacher will give you fifteen bean seeds. Suppose you wanted to find the volume of one of these seeds. Hold a seed in your hand and try to estimate what you think the volume is. Write down your estimate in Exercise 6 Question 1. How could you measure this volume? You can't measure it with a ruler because bean seeds do not have straight sides. You also cannot measure the volume with your graduated beaker because it is too small.

Can you think of a way of using all fifteen bean seeds to find the answer to this problem?

EXPERIMENT 14 : To find the volume of fifteen beans

You will need: your graduated beaker with the water in it
fifteen beans

Carefully pour away some of the water until you have 25 ml left in the beaker. Now the beaker is holding 25 ml (or 25 cm^3) of water. Drop in the beans. What happens to the water level?



Now answer the rest of Exercise 6 in your book.

That's a useful way of measuring volumes of objects which do not have a simple shape.

Now you have completed all your lessons on measuring instruments. You are well on the way to becoming a scientist! Remember to watch at all times for errors and to think about how good your measurements are.

How much do you know?

In your Exercise book, complete the following sentences WITHOUT LOOKING BACK in your book.

EXERCISE 7

1. We measure length using a _____ _____
   The unit of length is _____
2. We measure how hot or cold something is using a _____
   The unit of temperature is _____ .
3. We measure _____ using a balance. The unit is _____
4. We measure _____ with a clock. The unit is _____
5. We measure _____ in a graduated beaker. The unit is _____

PART 2

In the first part of this unit, you learned how to use some measuring instruments. These helped you to be more exact. You also learned that your five senses are not always the best guide to the true and exact facts.

However, a really good Scientist uses his senses AS WELL AS his measuring instruments to help him find out things. You will get some practice in this idea in this part of the unit. You will be asked to use eyes, ears, nose and fingers PLUS all your measuring instruments to help you to find out.

Before you do any more, you must have more practice in noticing things. This is called "OBSERVATION". You are going to mix some substances and write down all that you OBSERVE. Try to see EVERYTHING that happens. Also SMELL - use your NOSE. Also LISTEN - use your EARS.

EXPERIMENT 15 Observations made when substances are mixed

You will need: Your graduated beaker
A dropper

Your teacher will tell you what to do next.

Write all your observations in your Exercise book in table form when you have completed all your observations. (Exercise for Experiment 15)

Here is an example of how to set out your observations:

Test	Observation
5 ml Substance 1 (clear liquid smelling of ammonia) + 5 ml Substance 2 (blue liquid - no smell)	Some pale blue solid substance formed and sank to the bottom slowly. Ammonia smell almost gone.

WASH OUT YOUR BEAKER AND DROPPER VERY WELL WITH CLEAN WATER.

That was fun, wasn't it? Making accurate observations is one of the most important abilities a scientist needs. Practice using your senses to notice as much as you can.

That experiment used your EYES and NOSE and EARS. As a measuring instrument you used your GRADUATED BEAKER. In the next experiment you are going to use your EYES and the THERMOMETER as your measuring instrument.

You will look at a solid substance as it is warmed with the burner flame, and then observe it again as it cools down. When a solid turns into a liquid we say it MELTS. The temperature at which it melts is called the MELTING POINT. You will be able to find out the melting point of your solid in this experiment.

Experiment 16: to find the melting point of a solid substance.

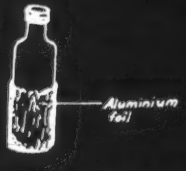
READ THROUGH ALL THE INSTRUCTIONS BEFORE YOU BEGIN

You will need:

- your boiling tin
- your peg
- your burner and stand
- your bottle

} from your basic kit

- a piece of aluminium foil
- 5 spatulas of naphthalene
- some water
- a clock
- a thermometer



Set up your burner and stand. Put water in the boiling tin until it is about three quarters full and heat it up until the water boils.

While you are waiting for it to boil, fold the aluminium foil in half Wrap it around the bottom of the bottle as shown in the diagram to make a small flat cup. Your teacher will put the naphthalene into the cup for you.

Please turn over

When the water is boiling, hang the little cup of naphthalene in the water using your peg as shown below. BLOW OUT THE BURNER FLAME.

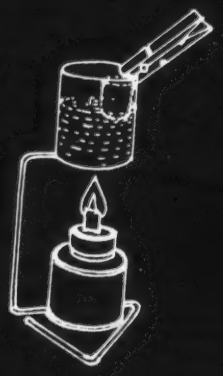


Diagram 5

You will see the naphthalene melting in the cup. As soon as it has melted, put the thermometer bulb into the cup and hold it so that the naphthalene covers the bulb. The temperature should rise to about 85°C. If it does not reach 80°C tell your teacher.

Watch the thermometer carefully. The temperature will soon stop rising. Now one partner should look at the clock, and the other look at the thermometer.

When the second hand passes the twelve, the clock watcher should call "now" and the thermometer watcher should call out the temperature at that exact time. Write it down in your books. Keep watching the clock and call the time EVERY 30 seconds (half minute), writing down the temperature each time.

Do this until the temperature reaches 70°C.
Set out your readings as follows:

Time/Minutes	Temperature/°C
0	- about 85°C
½	(Put your
1	readings
1½	here)
etc	to about 70°C

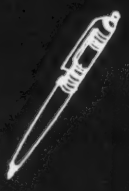
Go on taking readings until the temperature has fallen to about 70°C. The naphthalene will now be solid again and the experiment is finished.

So that you can remove the thermometer, light your burner and warm the water until the thermometer comes out easily. DO NOT TRY TO PULL IT OUT. When it is out dip it into the hot water to clean it and return it to your teacher. Keep the little cup of naphthalene in your basic kit box - you will need it later.

When a liquid starts to change back into a solid time is taken for this to happen. The temperature stays the same at this point, (the melting point or freezing point of the substance) for quite some time. Once the solid has all formed the temperature starts to fall again. You should be able to see the melting point of the naphthalene from your readings. What is it?

This is the first time that you have set up apparatus and carried out an experiment all on your own. Well done! It would be helpful to you if you wrote down all that you did.

The Exercise for Experiment 16 asks you to do the following:



1. Write down your readings (you have already done this)
2. Write down the aim of the experiment (what you wanted to find out)
3. Draw a diagram of the APPARATUS (similar to Diagram 5)
4. Write down what you actually DID in your OWN WORDS, not in the words of the book.
5. Write down what you discovered from the experiment (your CONCLUSION)

Now you have written a report!

Have you ever thought that you have a clock ticking inside you? Your heart pumps blood around your body. The working of the pump can be observed in your pulse. So the pulse is your ticking clock. But it is not a good measuring instrument because it changes. A doctor often measures your pulse to see whether your heart is working too fast.

EXPERIMENT 17 To measure a pulse rate

You will use the CLOCK and your FINGERS and EYES to measure your partners pulse rate.

You will need:
a clock
Your partner!

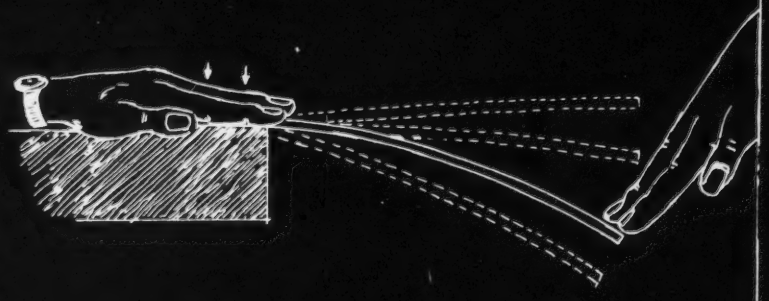
Find the PULSE in your partner's wrist.
Your teacher will help you if you have difficulty.
As the second hand passes the twelve, start counting the pulse beats. Count for one minute.
Record your partner's pulse in Exercise 10, Question 1.
Then your partner will measure your pulse rate.
Record this also. You could do a second reading as a check if you have time.

When you have measured your "sitting down" pulse, do some running on the spot for 30 seconds. Then measure your pulse again. What do you notice? Now complete Exercise for Experiment 17

You haven't really used your ears yet! The last experiment we shall do in this section uses your RULER as a measuring instrument and your EARS and EYES.

Experiment 18 : Matching sounds

You will need: your boiling tin
your ruler
an elastic band



Stretch the elastic band around the tin as shown. Pluck the elastic. It will make a nice "twanging" sound! Now put your ruler on your desk and move it about until the ruler and the elastic make the same note when "twanged" (as far as you can tell). Measure the length of ruler that sticks out from the desk. Record your answer in the given Exercise.

Now you are skilled in making measurements and in observing here are some problems for you to try.

EXPERIMENT 19 To measure the volume of a piece of polystyrene

You will need:

A small weight
A piece of polystyrene
Your graduated beaker
Some thread
Some water

In Experiment 7 you discovered how to find the volume of small beans. Finding the volume of the small weight is therefore no problem. The polystyrene, however, floats! What are you going to do?

When you have found the answer, record your results in the Exercise for this experiment.

EXPERIMENT 20 To find the mass of 25 cm^3 of water

You will need: Your graduated beaker
some water
a balance

Remember that you cannot put water directly onto the balance pan! What are you going to do?
When you have found out, record your result in the Exercise for this experiment.

EXPERIMENT 21 To find out which is hotter: your burner flame or the teachers Labgaz flame

This time you are not told what you will need! But remember.

1. You CANNOT PUT YOUR THERMOMETER DIRECTLY into the flame.
2. If one flame is hotter, it will heat things up more quickly than the other.

Your teacher will be able to give you some more hints if you are really puzzled. Then answer Exercise for Experiment 21

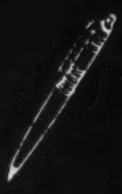
EXPERIMENT 22 To find the mass of a bean

Once again you are not told what you will need! But remember:

1. One bean has very little mass.
2. Many beans have quite a large mass.
3. Although the beans are not exactly the same size, they are nearly the same and can be taken to be the same for this experiment.

Think hard!

Than answer Exercise for Experiment 22



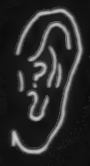
EXPERIMENT 23 To find the thickness of a page of this book

You will need:

Your ruler

The thickness of one page of the book is too small to measure with your measuring instrument. What can you do? Hint: think about Experiment 22 again.

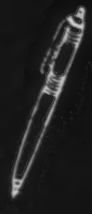
When you have found the answer, record your results in the Exercise for this experiment.



More interesting problems

Your teacher has set up some problem experiments around the class and you are asked to find out as much as you can using your senses. Record your observations under the headings "Test" "Observation" as you did before in Experiment 15.

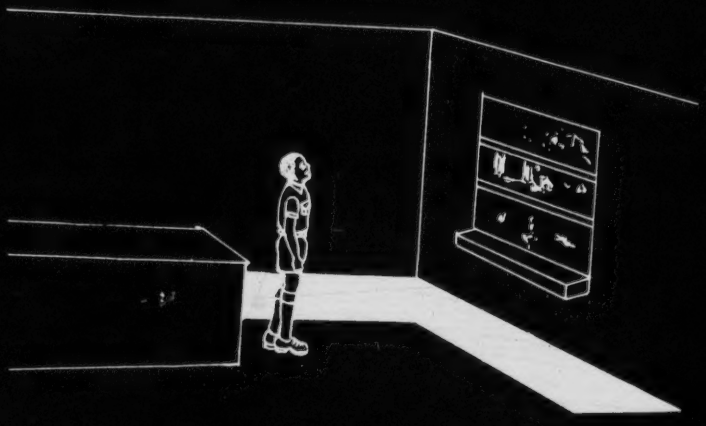
Experiment 24	Experiment 25	Experiments 26 & 27
Attracting other substances	A swinging weight. (a "pendulum".) Find out something about the time it takes for the pendulum to swing.	Two boxes What do you think there is inside each box? You may NOT open it!



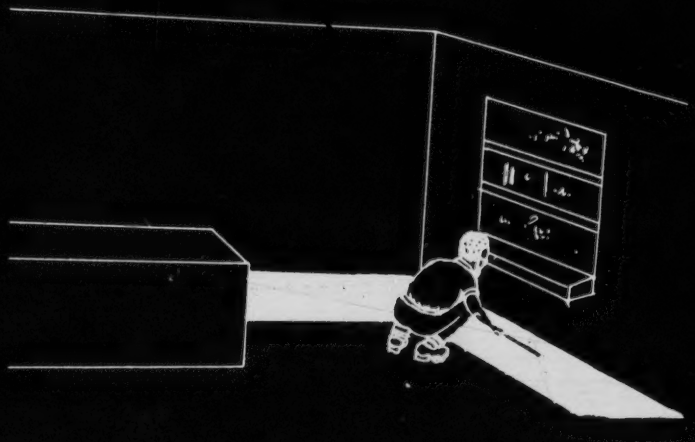
Record all your observations in the Exercise given.

PART 3 What to do with results

When a scientist makes observations and writes them down they are often called results.
Scientists are always interested in results. Sometimes one single observation is needed, but more often a lot of results give more information. For example, your estimate of the length of the classroom wall was a single guess.



But it would be wrong to think that all Form 1 students made the same guess. It is better to take the results for your whole class, and to find the AVERAGE.
Probably this would be close to your teacher's result, but not exactly the same.



The more guesses taken the closer the average would be. Most Form 1 girls and boys would be close to the average result, but a few would be quite different. I wonder what your class average would be? It is quite a long sum to work it out, and the arithmetic gives us no idea of how far away from the average some guesses were.

A much better way to show all the guesses for a class is by using a diagram called a HISTOGRAM. In Diagram 6, some guesses for a room which was actually 9.0 metres long are shown on a histogram.

Look at what the teacher has done to show all the guesses. There were 43 children in the class. No one guessed less than 7,0 m or more than 10,5 m.
So, he decided to group the guesses into:

Number of children who guessed between 7,0m and 7,5m = 2
" " " " " " 7,5m and 8,0m = 4
" " " " " " 8,0m and 8,5m = 7
" " " " " " 8,5m and 9,0m = 14
" " " " " " 9,0m and 9,5m = 8
" " " " " " 9,5m and 10,0m = 5
" " " " " " 10,0m and 10,5m = 3

The number of children who made each guess is put on the vertical axis. Find where it says "number of children" on the histogram. The actual guesses are put on the horizontal axis. Find "length of wall in metres" on the histogram.

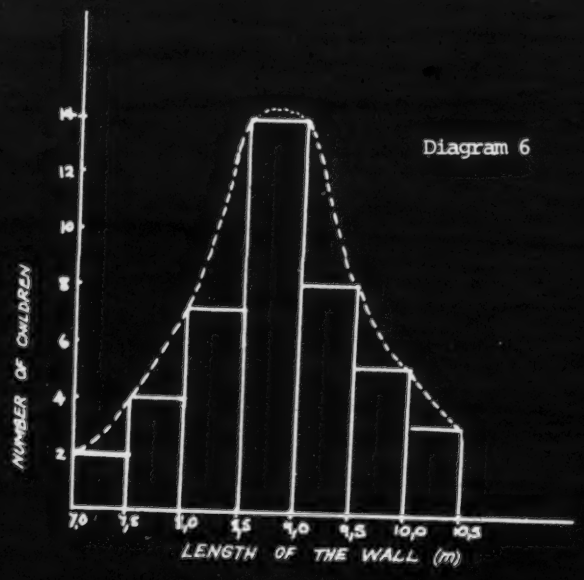
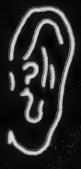


Diagram 6

Now look at the first piece of the histogram (The left hand side) Two children made the same guess. Their guesses were between 7,0 and 7,5m. So a box is drawn to show this group. More boxes are drawn for each of the other groups, and then a picture forms of the class results. You will see that most guessed the right measurement, or close to it. When the pattern of results makes this kind of shape, with a big peak at the middle, we call it a NORMAL pattern. Many things might follow this pattern, such as the ages of the pupils in your class or the guesses you made at temperature or time.

Now it is your turn to make a HISTOGRAM. Call out your guesses from Exercise 2 to your teacher. He will group them on the board, together with the number of children who guessed that measurement and you can construct your own histogram.



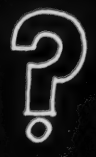
Is it a normal pattern? Discuss this with your teacher.

You will do more work on histograms and on normal patterns in the next unit.

How much do you know?

In your Exercise book, complete the following sentences WITHOUT LOOKING BACK in your book.

1. I would find out the melting point of a substance using a _____
   I could not use this measuring instrument if the melting point was above _____ °C or less than _____ °C.
2. To find the volume of a floating object, I should _____
   _____
   _____
3. To measure a very small length such as the thickness of paper I could _____
   _____
   _____
   _____
4. To measure a very small mass such as the mass of a bean, I could _____
   _____
   _____
   _____



Now you have really started on the road to being a scientist. You have worked very hard, and deserve to make progress. Well done!

Summary : Unit A1

1. A scientist uses measuring instruments together with his five senses to discover things.
2. For measuring length, a metre rule is used. Short lengths may be measured with a ruler. The unit of length is a metre (m).
3. For measuring temperature, a thermometer is used. The unit of temperature is degrees Celsius (^{o}C).
4. For measuring mass, a balance is used. The unit of mass is the kilogram (kg)
5. For measuring time, a clock is used. The unit of time is the second (sec.)
6. For measuring volume, a graduated beaker can be used. The unit of volume is the cubic metre (m^3)
7. Volume, mass or length of a small thing may be measured by finding the result for many and dividing to get the result for one thing only.
8. Results obtained by scientific experiment are best shown on a graph such as a HISTOGRAM.
9. Never forget NO measurement is completely accurate. ALL measurements have an error in them.

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